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COMMISSION OF THE EUROPEAN COMMUNITIES

Multiannual programme
of the Joint Research Centre
1980-83

1982
Annual Status Report

Nuclear measurements

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N U C L E A R M E A S U R E M E N T S
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PROJECTS

- project Measurements of Nuclear Data:
  neutron data
  non neutron nuclear data
- project Nuclear Reference Materials and Techniques:
  nuclear reference materials
  samples and targets for nuclear measurements
  development of reference techniques
  study for the production of enriched actinide isotopes

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1. INTRODUCTION

The JRC programme "Nuclear Measurements" is carried out exclusively by the Geel Establishment (the Central Bureau for Nuclear Measurements, CBNM), and forms by far the largest fraction of the work commitment of that Establishment. It conforms closely with the aim of the Establishment as envisaged in the Treaty establishing the European Atomic Energy Community. In addition it is designed to extend the exploitation of the CBNM's major nuclear measurement facilities, the performances of which have been increased and improved in recent years. These include the two large accelerator installations (the electron accelerator and the Van de Graaff generator) and the mass spectrometers.
The Nuclear Measurements programme is divided into two main projects, Nuclear Data on the one hand and Nuclear Reference Materials and Techniques on the other.

In the former the JRC actions form part of world-wide sets of actions to establish reliable, and in many cases very precise, figures for important nuclear parameters - e.g. neutron interaction cross-sections, radionuclide half lives - needed for the development and exploitation of nuclear energy for peaceful purposes. In this work the CBNM pays particular attention to the specific needs of the Community and to complement similar actions undertaken in the laboratories belonging to the Member States.
Concerning Nuclear Reference Materials and Techniques the actions are to provide materials to which analytical and other measurements carried out in the nuclear industry or by the nuclear community can be referred. One or more of the properties of the materials must therefore be well characterized and eventually certified and in order to

carry this out effectively the important techniques used for characterization must be continuously examined and if possible improved.
The basic aim of the Nuclear Measurement programme is therefore to develop nuclear metrology with special orientation towards satisfying the demands for basic nuclear data and for materials and methods of reference.

2. RESULTS

Measurements of Nuclear Data

This project is divided into two parts, one concerned with data pertinent for neutron induced reactions and the other with so-called non-neutron nuclear data, i.e. mainly data on radionuclide decay.

Neutron Data

The main objective is to measure accurate differential cross section data needed for fast reactor design and safety, long term irradiation effects on fuel and structural materials, shielding, nuclear waste treatment and storage, safeguards and also for fusion reactors and technology. A prime objective for CBNM remains the improvement of the knowledge of standard cross sections required for these research areas. Also the understanding of underlying physics mainly concerning neutron induced reactions necessary for current and future nuclear power technology is an important objective.
During 1982, time compression of the pulses from the particle accelerators has been demonstrated. In the case of the 150 MeV linear accelerator this has been achieved by passing the accelerated electron beam through a special designed magnet (Fig. 1). For the Van de Graaff, using a spiral resonator a timing resolution of 330 ps has been obtained for a 3 MeV deuteron beam which is at least a factor 4 better than the resolution without bunching applied. Another major facility, the control processing unit, has been improved during 1982, by the replacement of the IBM 370/138 with an IBM 4341/I and this has led to a reduction of the execution times for batch programmes by a factor between 5 and 6 and of the response times for interactive operations by an order of magnitude.

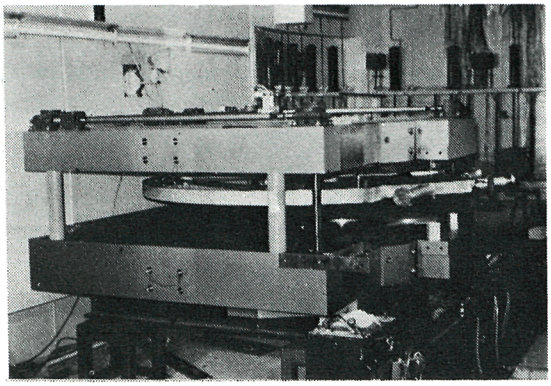

Fig. 1. Magnetic pulse compression at the Linear Accelerator.

An International Conference on Nuclear Data for Science and Technology, held in Antwerp, Sept. 1982, and organized by CBNM, provided a good focal point for CBNM work in nuclear data. Altogether there were 18 scientific contributions from CBNM to the conference. (Fig. 2).
Fission cross-sections for two isotopes of Plutonium ^{238}Pu and ^{242}Pu, have been measured over the neutron energy range from 5 eV to 10 MeV; results for ^{238}Pu are available (Fig. 3) but analyses of the raw data for ^{242}Pu have not yet been completed.
Data obtained on neutron capture by ^{56}Fe shows a discrepancy in the resonance region with data obtained at Oak Ridge National Laboratory (US). In view of the importance of this parameter, the discrepancy is under more detailed study by the NEA (Nuclear Energy Agency) Neutron Data Committee.

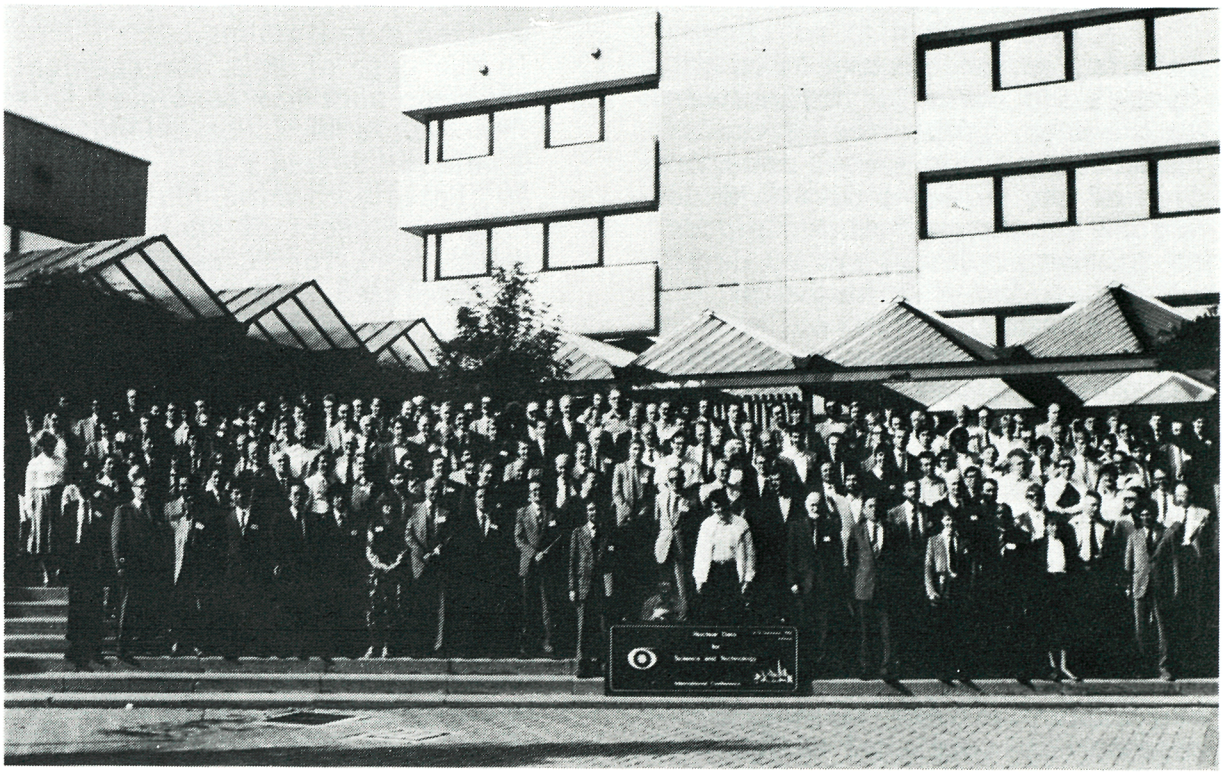

Fig. 2. "International Conference on Nuclear Data for Science and Technology" organized by CBNM.

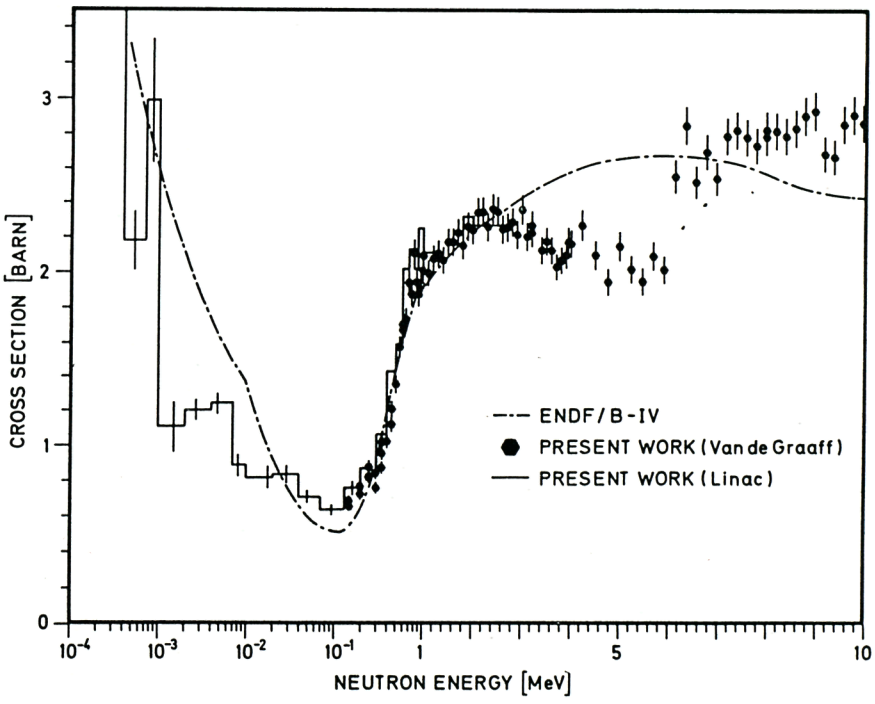

Fig. 3. Piezo-electric pulsed jet device developed for preparation of thin films.

Non Neutron Nuclear Data

In this section the objective is to meet the needs for information on the decay properties of radionuclides by experimental determination of the relevant data (including the development of techniques to improve accuracy) and by detailed evaluations of information already available.
During 1982 considerable emphasis was placed on studies of the decay properties of some actinides. Measurements of the alpha and photon emission rates in the ^{238}Pu to ^{234}U decay have been performed and work has started on the determination of 60 keV γ-ray emission probability in the decay of ^{241}Am.
In addition the published measurements of the half lives of ^{237}Pu and ^{242}Cm have been reviewed and assessed and evaluated values have been recommended. We have continued to participate in intercomparisons of radioactivity measurements organized by the Bureau International des Poids et Mesures (BIPM). During 1982 two contributions were made, for ^{133}Ba and ^{137}Cs respectively, the latter yielding satisfactory results.

Nuclear Reference Materials and Techniques

This project is divided into four parts.

Nuclear Reference Materials

There exists a need for certain actinide reference materials within the European Community. This need, and the priorities for the various materials, were established a few years ago and CBNM is now engaged in trying to satisfy the need.
Three types of such material, necessary for the calibration of analytical methods, can be identified: those for destructive chemical analysis, those for destructive isotope analysis by mass spectrometry and those for non destructive isotope analysis by measuring the emitted γ radiations.
In the case of RM's for chemical analyses work has continued to establish stocks of EC certified Pu metal, U metal, UO_2 and PuO_2.
As indicated in the last Programme Progress Report of Nuclear Measurements, work for Pu metal and U metal is completed, the certificate for Pu was issued in 1981 and a certificate for U was issued in 1982. In the case of UO_2 a little more work has been required to bring it to the point of final certification, but this is expected early 1983.
Regarding PuO_2 a programme of required analytical work has been made and delivery of the base material to CBNM is awaited.
Similarly, emphasis has been placed on establishing uranium and plutonium isotopic reference materials. As primary standards these will be sets of carefully prepared synthetic mixtures of the main isotopes. In the case of uranium, test mixtures with $^{235}U/^{238}U$ ratios of about unity have been prepared, the accuracy on the ratio being about 10^{-4}. It is hoped to achieve a final accuracy of about 10^{-5} and good progress has been made in this direction by a thorough purification of the samples of reported isotopes and a measurement of the remaining impurities. In the case of Pu a completely new glove box facility has been installed and preliminary tests of the chemical procedures have been carried out.
Negotiations with USA laboratories concerning collaboration to make plutonium reference materials, based on the primary isotopic mixtures, are in progress.
In collaboration with NBS-Washington CBNM has provided the characterized samples for an interlaboratory measurement evaluation programme so-called IDA-80 for the measurement of U and Pu element concentrations and isotope abundances; excellent agreement was obtained between the CBNM and NBS characterization values. The results from about 30 participating laboratories have undergone a preliminary evaluation.

Samples and Targets for Nuclear Measurements

During 1982 a total of 632 specialized samples and targets have been delivered to clients mainly in the Community. These are mainly in the form of thin films, used as nuclear targets in accelerating machines, or alloys for in pile dosimeters.

Reference Techniques

The object of this project is to develop and improve analytical methods and characterization techniques used for the production of reference materials and special samples and targets. An interesting new method for laying down thin films of rare and/or expensive materials has been developed, based on the adaptation of a piezo-electric pulsed jet device used commonly for character printing. Although the quality of the deposited film is not quite as good as can be obtained by other methods, it seems that the method can be used with negligible loss of material (Fig. 4).

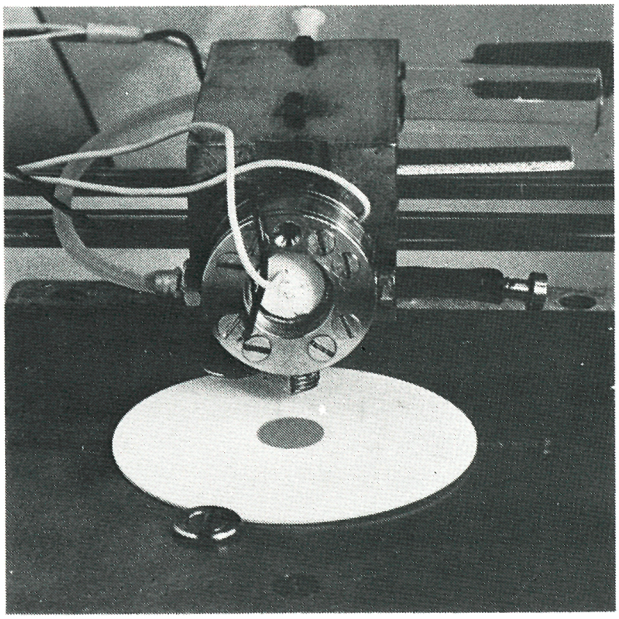

Fig. 4. Piezo-electric pulsed jet device developed for preparation of thin films.

A new installation for making measurements on thin films by the Rutherford backscattering and Proton Induced X-ray emission (PIXE) technique under ultra high vacuum conditions has been installed on the 3.7 MV Van de Graaff. The feasibility of measuring temporal variations of air pollution by using the PIXE method on streaked air filters has been demonstrated and it is hoped to apply this to measurements of air pollution along the North Sea Coast of continental Europe.

Study of the Production of Enriched Actinide Isotopes

Preliminary studies on the EC-requirements for enriched actinide isotopes for several purposes and the costs of producing them have now been made. These were issued to the ACPM Nuclear Measurements who have now advised not to go ahead with enriched isotope production in the next multiannual programme. A design study for a medium current electromagnetic separator has been made, under contract, by CNRS Orsay. In another contract with AERE, Harwell the performance of ion source of the Harwell Mark IV Isotope Separator has been evaluated for separation of isotopes of masses greater than 200.

3. CONCLUSIONS

Substantial contributions to the knowledge of neutron cross-sections have continued to be made in the course of 1981 and these were focussed at the International Conference on Nuclear Data for Science and Technology held in Antwerp, Sept. 1982. This Conference also pointed up important work to be carried out in the future. First tests on the pulse compression systems added to the two main CBNM accelerators are very encouraging and these modifications should

extend both the range and quality of future neutron data work.
The work towards preparing EC Certified Nuclear Reference Materials is now gaining pace. Two NRM's for destructive chemical analyses can now be issued with certificates and the formalities for a third are almost complete. Emphasis is being placed on preparing primary standards for U and Pu isotopic measurements. Provision of samples and targets continues to be an important service to customers, with 632 items delivered during the year.
Considerable knowledge has been accumulated in relation to separating actinide isotopes for research purposes, including a complete design study of a prototype electromagnetic separator. Due to anticipated high production costs, it is unlikely that this study will enter a prototype production phase in the foreseeable future.
The mutual collaboration with external organizations has continued. Such collaborations are essential to ensure the full exploitation of the Linac accelerator in the area of nuclear data measurements and also in the characterization and verification work for nuclear reference materials.

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